Occupant Health in R-2000 Houses,
Preliminary Results of a Health Canada Survey

Introduction

Health Canada has been studying people's health before and after moving into new R-2000 houses and similar new conventional (non-R-2000) houses. The study was begun in 1996, and now includes 312 people living in 105 houses in New Brunswick and Nova Scotia. Telephone questionnaires were conducted before or just after the move, and about one year after moving into the new house. Changes in each of fourteen symptoms were noted for each member of the household, and the total amount of the changes determined whether there was a general improvement or deterioration of health after moving to the new house. The preliminary results clearly indicate that people who moved into R-2000 houses found that their heath improved more than those who moved into conventional houses.

The R-2000 Program

The R-2000 Program certifies houses which meet strict criteria for energy efficiency, ventilation, and construction practices. R-2000 builders are specially trained and certified, and the plans and construction of each house are evaluated and inspected by trained, licenced professionals. Houses are individually tested for airtightness, and certified to be R-2000 houses by Natural Resources Canada. When the program began in 1982, it was mainly concerned with energy conservation, but it has evolved to include requirements for materials and water conservation, indoor air quality, and a healthier, more comfortable living environment. Key features of R-2000 houses include:

- increased insulation and air-tightness,
- passive solar gains and high-performance windows,
- increased energy efficiency,
- less water consumption and sewage production,
- reduced construction wastes,
- no "spillage susceptible" combustion equipment,
- fresh air (mechanical ventilation) to all rooms,
- environmentally friendly products, and
- healthy building materials and finishes.

Many of these features are specifically intended to improve indoor air quality and health, and measurements of indoor pollutants such as formaldehyde and volatile organic compounds have shown that levels are lower in R-2000 houses as compared with similar conventional houses. But until now there has been no direct study comparing the health of people in R-2000 and other houses.

The Health Canada Survey

In collaboration with Natural Resources Canada, Health Canada has studied changes in health of 146 people who moved into 53 new R-2000 houses, and 166 people who moved into similar new conventional (non-R-2000) houses. The survey was conducted in New Brunswick and Nova Scotia due to the general concern with air quality problems in that region, and due to the large number of R-2000 houses being built there. Local consultants, builders and real estate agents helped to identify households who were planning to move into suitable houses.

Health Canada administered a telephone baseline questionnaire to one member of each household (the respondent) before, or as soon as possible after, the move to the new house. The questionnaire covered (1) characteristics of the house they were moving from, including perceptions of its indoor air quality, (2) the demographics, general level of health, and medications taken by of each member of the household, and (3) whether each member of the household showed each of thirteen symptoms never, sometimes, often or continuously. The symptoms are headache, fatigue, dry or itchy skin, runny nose, blocked nose, sneezing, throat irritation, cough, wheeze, nausea, diarrhea, difficulty concentrating, and irritability. Some of these symptoms were selected because they are often the effects of poor indoor air quality, while others are "control" symptoms which should not be affected by the house.

Some of the baseline characteristic of the people who moved into the R-2000 and conventional houses are shown in Table 1. The number of houses and people are fairly evenly matched, and the numbers of people with allergies and chronic bronchitis are almost equal. However, only half as many of the R-2000 people smoke, and there were approximately half as many R-2000 people with asthma, or using regular medication for breathing problems or allergies. The numbers of smokers may indicate a higher level of concern for health in the people who moved into R-2000 houses, while the numbers for asthma and medication may indicate that they were more healthy initially. However, since the survey is about changes in health, differences in initial health are probably not relevant.

Approximately one year after the household had moved into their new house, the same respondent was contacted for the follow-up questionnaire. The follow-up repeated most of the questions in the baseline questionnaire, including those about the frequency of each symptom in each member of the household. Changes in symptoms for each household were scored as follows: Each change in frequency of occurrence of each symptom for each member is counted as plus or minus one, with improvements given a positive value, and deteriorations a negative value. For example, if a person's headaches change from Continuously to Often, then his headache score is +1; if someone's fatigue symptoms change from Often to Never, then her fatigue score is +2, and if her sneezing symptoms go from Never to Continuously then her sneezing score is -3. These individual symptom scores were analysed in two ways:

	R-2000 houses	Conventional Houses
Number of houses	53	52
Number of people	146	166
Smokers	6	12
Allergies	35	34
Asthma	7	15
Chronic Bronchitis	2	2
Medication for breathing	7	15
Medication for allergies	10	16

Table 1. Baseline data: number of houses, people, and people with various characteristics moving into each type of house.

First, the symptom change in each house was determined by summing the individual symptom scores of each member of the household for each symptom. For example, if there are three members, and their sneezing scores were +3, -2 and +1, then the sum is +2, so sneezing got better in that house. The percentage of R-2000 and conventional houses in which each symptom got better or worse were compared and analysed statistically. Second, for each member, the changes in all thirteen symptoms were summed to get a member score, and the member scores were summed to get a score for the new house. A positive house score indicates a general improvement in health since moving into the new house, while a negative score indicates a general worsening.

The Results

Table 2 shows the symptom changes in R-2000 and conventional houses. For all thirteen symptoms, the improvement in the R-2000 houses was stronger than in the conventional ones. The 'p' values are a measurement of how likely it is that the difference between the R-2000 and conventional houses could be due to chance. For example, the .07 for headache means that there is only seven chances in 100 that the difference is due to chance, while for fatigue there is less than one chance in 100 (9 in 1000). A 'p' value of 0.01 or less is generally considered statistically significant, so five of the thirteen differences between the R-2000 and other houses are significant. The symptom with the lowest significance, diarrhea, is a "control" which should not relate to air quality.

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Symptom	% of houses with improvements		'p'
	R-2000	Conventional	Value
Headache	27%	18%	.07
Fatigue	37%	23%	.009
Dry skin	25%	18%	.11
Runny nose	28%	16%	.01
Blocked nose	23%	18%	.25
Sneezing	28%	16%	.02
Throat irritation	31%	17%	.004
Cough	36%	20%	.002
Wheeze	13%	7%	.08
Nausea	13%	10%	.37
Diarrhea	16%	18%	.59
Difficulty concentrating	18%	14%	.28
Irritability	39%	22%	.002

Table 2. Symptom Change: R-2000 vs. Conventional Houses.

Table 3 shows how house scores compare for R-2000 and conventional houses. R-2000 houses show much better results in all of the categories:

- the highest score for an R-2000 house is more than one-and-a-half times higher, indicating a much stronger improvement in health,

- the average R-2000 house improved by 6.2 while the average conventional house got slightly worse,

- the lowest score in a conventional house is more than twice as low as in any R-2000, indicating a more serious decline in health,

- almost twice as many R-2000 houses showed improvements, while more than two-and-a-half times as many conventional houses showed worsening health.

The fact that some people got worse in both R-2000 and conventional houses does not mean that either type of house makes people sick. In any large sample of people, some will get sicker. It is the differences between the numbers who got better and worse that indicate the health benefits of the two types of houses.

	R-2000 houses	Conventional houses
Number of Houses	52	53
Highest score	+57	+36
Average score	6.2	-0.5
Lowest score	-21	-43
Better	75%	38%
No change	6%	13%
Worse	19%	49%

Table 3. Comparison of House Scores for R-2000 and conventional houses.

They way respondents rated some of the characteristics of their indoor air quality is shown in Table 4. Twice as many occupants of conventional houses found them too dusty or too humid, compared with R-2000 houses, and significantly more found their conventional houses too dry or too drafty. When asked whether they felt that the indoor air quality was better in their new houses than in their old ones, 94% of R-2000 occupants said yes, compared to 77% in non-R-2000 houses. When asked whether their general health had improved or deteriorated since moving to their new houses, 32% of conventional house occupants reported improvements and 10% reported deteriorations; in R-2000 houses 56% reported improvements and none reported deteriorations. The percentages reporting general improvements are reasonably consistent with the "Better" house scores in Table 3. The percentages reporting general deteriorations are not very consistent with the "Worse" house scores, but they do agree that there are fewer deteriorations in R-2000 houses.

	R-2000 houses	Conventional houses
Too Dusty	15%	30%
Too Humid	2%	4%
Too Dry	25%	36%
Too Drafty	4%	6%

Conclusions

It is important to realize that these results are preliminary for two reasons. First, they have not yet been peer reviewed, and second they could be significantly changed by the results of the second phase of the project which will include an additional houses (see below). Still, the results strongly indicate that people who moved into R-2000 houses found that their heath improved more than those who moved into conventional houses. This result is shown consistently by the scores for individual symptoms, house scores, and occupants' perception of their general health.

It is also consistent with occupants' perceptions of their indoor air quality. Thus, the first direct study of the health effects of R-2000 houses provides a clear indication that the R-2000 Program's focus on improving indoor air quality does result in better occupant health.

Future Studies

Natural Resources Canada with the assistance of Health Canada has made physical measurements of air quality in twenty of the houses in the original survey. The houses selected for these measurements included the R-2000 and conventional houses with the most significant improvements and deteriorations in health. The measurements include air change rates, mould species and counts, allergens, formaldehyde, and volatile organic compounds. When the results are analysed they may provide specific information on why some houses are healthier than others, and this should lead to further improvements in the health characteristics of both R-2000 and conventional houses.